(12) UK Patent Application (19) GB (11) 2 105 517 A

(21) Application No 8224509
(22) Date of filing 26 Aug 1982
(30) Priority data
(31) 297439
(32) 28 Aug 1981
(33) United States of America (US)
(43) Application published 23 Mar 1983
(51) INT CL[3] H01G 5/24
(52) Domestic classification H1M 2A 2F 2P4 2P5 BT B6F CP U1S 2028 B6F H1M
(56) Documents cited
GB 1551960
GB 1520899
GB 1399251
(58) Field of search H1M

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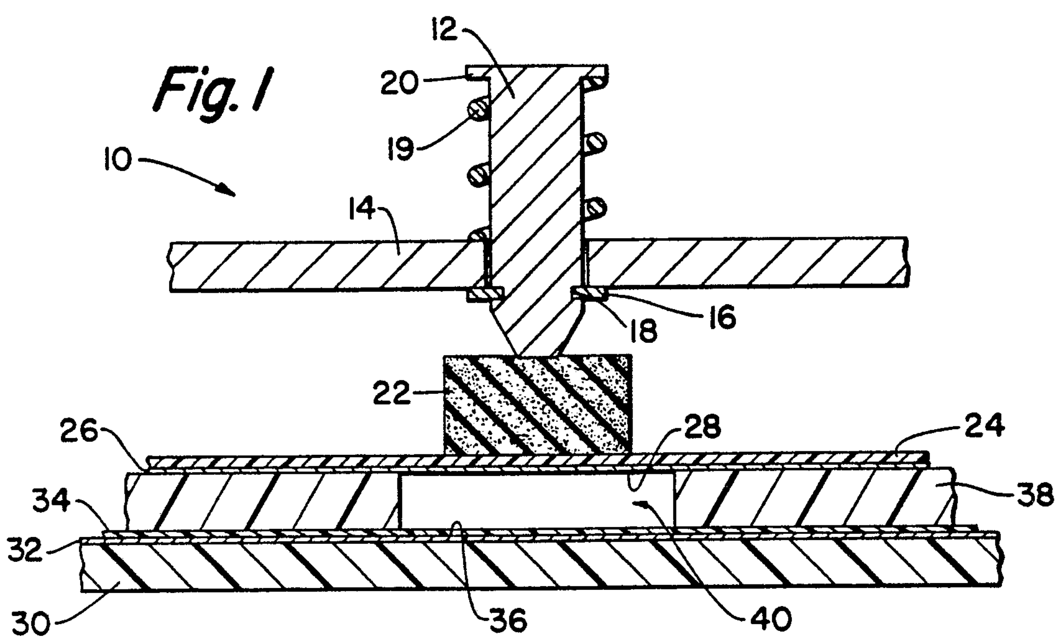
(54) Capacitive keyswitches

(57) A capacitive keyswitch for a keyboard, and comprising an upper flexible membrane 24, a first conductive circuit pattern 26 formed on the lower surface of said upper flexible membrane and including a first conductive land 28, an electrically insulating spacer 38 having an aperture 40 therein over which said first conductive land lies, a second conductive circuit pattern 32 positioned below said first circuit pattern and including a second land 36 positioned below said aperture so as to face said first conductive land 28, an insulating dielectric layer 34 of a substantially smaller thickness than said spacer 38, disposed between said first and second conductive lands 28, 34, and an actuating member 12 arranged to deflect said upper flexible membrane and said first land towards said second land.

Fig. 1



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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Fig. 1

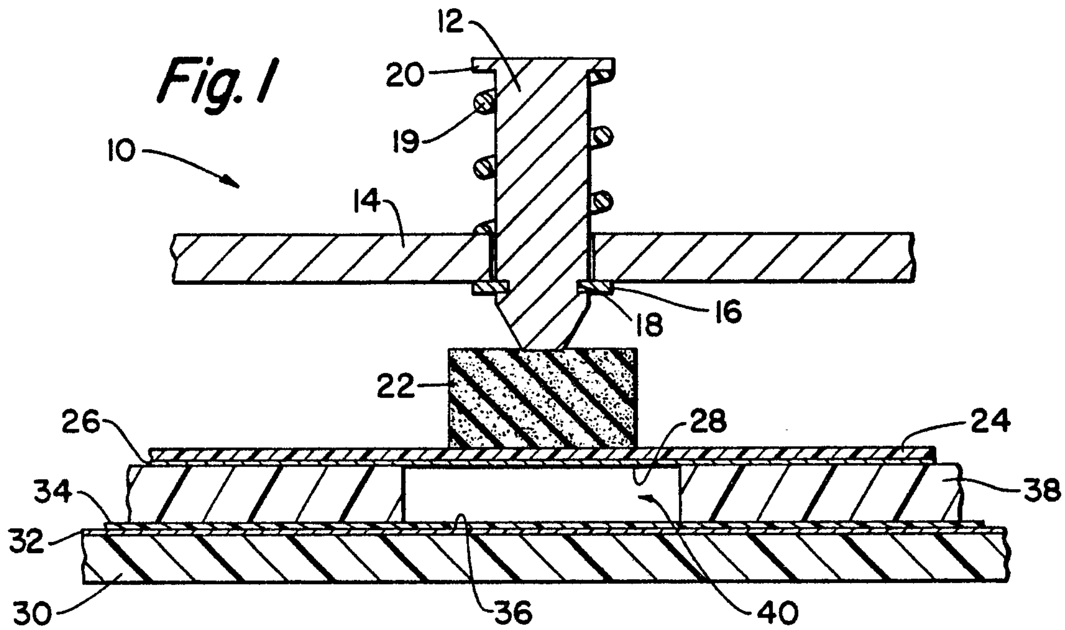
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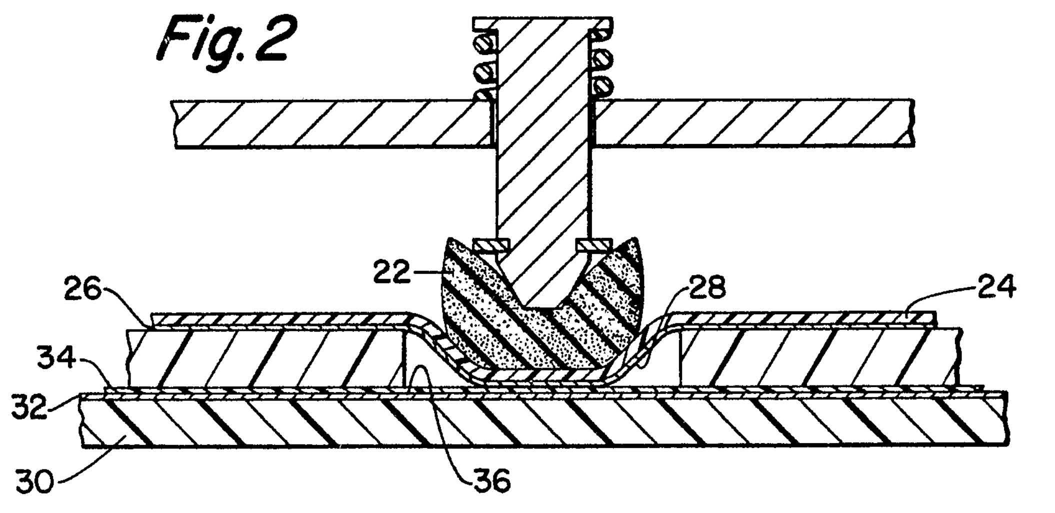
Fig. 2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SPECIFICATION

Capacitive keyswitches

Thin contact membrane keyswitches do not offer the extreme high reliability of other types of keyswitches, for example, such as the magnetic core keyswitches of the type shown in United States Patent No. 4,227,163 issued October 7, 1980 to Raymond Barnoski and assigned to Illinois Tool Works Inc. Contact membrane keyswitches, however, do offer sufficient reliability for many applications at an appreciably lower cost. One type of contact membrane keyboard is described in the article wanted "Touch Panel Switches are Based on Membrane Switch Concept", published in *Computer Design,* December 1979. In this type of keyswitch, two spaced-apart membrane layers coated with aligned conductive contact lands are separated in an aperture formed in a spacer. When the upper flexible membrane is depressed, contact is made between the upper and lower conductive lands to close the switch. Being a contact switch, however, it does have the inherent deficiencies of all contact switches, which include wear, and the possibility of oxidation and corrosion of the conductive areas.

While capacitive keyswitches are desirable because of their potential greater reliability and longer life, such keyswitches as have been designed in the past have been appreciably more expensive than a simple contact membrane switch.

Another membrane contact switch is disclosed in United States Patent No. 3,676,607, issued July 11, 1972 to Donald H. Nash et al and assigned to Bell Telephone Laboratories, Inc. This patent shows a keyboard employing field effect transistors, and it was recognised that actual contact between the conductive lands did not have to occur because the field effect transistors could be controlled by capacitance change if contaminants intervened between conductive upper and lower lands. However, the keyswitch of this patent was still designed to be basically a mechanical switch; and moreover, the design led to a split lower land area configuration of two lower lands which resulted in a capacitive keyswitch in which the available capacitive plate area is divided in half and relatively complicated detection circuitry was required.

Another capacitive membrane keyswitch is described in an article entitled "Capacitive Membrane Keyboard Bars Contamination", which appeared in *Electronic Products Magazine,* June 15, 1981 issue. This capacitive keyswitch is designed by Microswitch/Honeywell, and it employs an upper flexible membrane that carries a conductive land above a second membrane which has a second conductive land that is aligned with the upper conductive land. The two conductive lands are positioned in an aperture in a spacer which allows the upper members and land to be deflected towards the lower land until contact is made. Thus the actual switching action is of the contact type. On the bottom of the lower membrane, however, there is another conductive area. The conductive coatings on both sides of the lower membrane, therefore, provide a fixed capacitance, while the movable upper membrane provides a variable capacitance that is in series with the fixed capacitance. Although theoretically the two facing lands at a keyswitch do not have to be brought into contact with each other, in practice they must be in such a close proximity that the keyswitch will rely on actual contact to operate.

In the present invention, the simple technology of the membrane contact keyswitch can be utilised, with the only change required being the provision of a dielectric layer between the upper and lower conductive lands which thereby provides a keyswitch with a high capacitance that has the simple construction of a contact membrane switch.

According to the present invention a capacitive keyswitch comprises (when considered in an upright attitude) an upper flexible membrane, a first conductive circuit pattern formed on the lower surface of said upper flexible membrane and including a first conductive land, an electrically insulating spacer having an aperture therein over which said first conductive land lies, a second conductive circuit pattern positioned below said first circuit pattern and including a second land positioned below said aperture so as to face said first conductive land, an insulating dielectric layer of a substantially smaller thickness than said spacer, disposed between said first and second conductive lands, and an actuating member arranged to deflect said upper flexible membrane and said first land towards said second land.

In a keyboard embodying such keyswitches, there is an upper flexible membrane with a first pattern of interconnecting conductive areas deposited on it at each key station of the keyboard. A second pattern of interconnecting conductive areas is deposited on a substrate below the first pattern. At each key station the conductive lands are aligned with each other. An electrically insulating spacer separates the pair of conductive lands at each key station when the keyswitch is unactuated.

In one embodiment of the keyboard a dielectric film layer lies over all of the bottom conductive land areas and over the entire lower second circuit pattern.

In another embodiment, a dielectric layer is deposited on at least one of the conductive lands at each key station, and consists of a polymer dielectric film or other suitable dielectric coating. The polymer film may be a solder mask material.

In still a further embodiment, the lower and upper conductive areas may be made of an oxidisable metal, such as aluminium or tantalum, which has its surface oxidised in an oxidising atmosphere to form a thin insulating dielectric layer on one or both of the lands of each key station.

An elastomeric cushion may rest on top of the upper membrane, so that when the actuator of the keyswitch is depressed it will cushion the force of the actuator so as to protect the upper membrane and may provide some return bias force.

The accompanying drawings show one example of a keyswitch embodying the present invention. In these drawings:—

Figure 1 is a cross-sectional view of the keyswitch in an unactuated condition; and

Figure 2 is a cross-sectional view of the keyswitch of Figure 1 is an actuated condition.

Figures 1 and 2 show a fragment of a keyboard structure, just sufficient to permit description of one keyswitch 10. The keyswitch consists of an actuating plunger 12 which is attached to a keycap (not shown) and is retained in a chassis 14 by a retaining washer 16 in a groove 18 of the plunger, or by other conventional retaining methods. A bias spring 19 may be connected between the top surface of the chassis and the bottom of a rim 20 of the plunger to provide for return of the plunger after release of pressure on it. A pad 22 of elastomeric material is disposed below the plunger 12, and it rests on the top surface of a flexible membrane 24 of a plastics film material, such as polyethylene, polypropylene, or other suitable material, such as that known as MYLAR (R.T.M.). The bottom surface of the flexible membrane 24 carries a first relatively thin film 26 of conducting metal which forms an interconnecting circuit pattern including a first conductive land 28. A base 30 has on its upper surface a second thin film 32 of conducting metal which forms a second interconnecting circuit pattern including a second conductive land 36 that is aligned with the first land 28. A relatively thick dielectric spacer 38, which may be a MYLAR film, is interposed between the thin films 26, 32, and in the spacer there is an aperture 40 aligned with the lands 28, 36. When the keyswitch is in unactuated condition, as shown in Figure 1, the lands 28, 36 are separated by substantially the thickness of the spacer 38.

In the illustrated embodiment of the present invention, a thin dielectric layer 34, such as any suitable plastics film material used for film capacitors, and which has a much smaller thickness than the spacer 38, is placed over the conducting film 32 including the land 36. The film 32 is shown as being deposited directly on the supporting base 30, although the film 32 could be deposited on a second plastics dielectric layer supported by the base instead of on the base itself.

When the plunger 12 is depressed, the upper membrane is deflected as shown in Figure 2. The elastomeric pad 22 acts as a cushion which protects the upper membrane 24 and provides overtravel. The pad 22 also provides a measure of return bias force when pressure on the plunger 12 is released. When the conductive lands 28 and 36 are in close proximity to each other, as shown in Figure 2, due to the depression of the plunger 12, the thin dielectric separating layer 34 contacts both of the lands 28, 36 and this results in a relatively large capacitance value when the switch is in the actuated position, illustrated in Figure 2.

The keyswitch can also achieve the desired high ratio of ON to OFF capacitance by replacing the illustrated thin film 34 plastics layer with any other suitable dielectric material such as a conventional polymer dielectric film layer deposited on either, or both, of the facing surface lands 28 and 36. Another approach to providing a desired dielectric insulation layer would be to utilise a readily oxidisable metal for one or both of the lands 28, 36, for example, aluminium or tantalum, which has its surface oxidised to provide a very thin insulating layer and a high dielectric constant which would enable manufacture of a still thinner keyswitch.

CLAIMS

1. A capacitive keyswitch comprising (when considered in an upright attitude) an upper flexible membrane, a first conductive circuit pattern formed on the lower surface of said upper flexible membrane and including a first conductive land, an electrically insulating spacer having an aperture therein over which said first conductive land lies, a second conductive circuit pattern positioned below said first circuit pattern and including a second land positioned below said aperture so as to face said first conductive land, an insulating dielectric layer of a substantially smaller thickness than said spacer, disposed between said first and second conductive lands, and an actuating member arranged to deflect said upper flexible membrane and said first land towards said second land.

2. A keyswitch as claimed in claim 1, wherein said insulating dielectric layer is a thin plastics dielectric film layer.

3. A keyswitch as claimed in claim 1, wherein said insulating dielectric layer is a polymer film.

4. A keyswitch as claimed in claim 3, wherein said polymer film is a solder mask material.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.